Silvoarable agroforestry in Europe
Systems for meeting food and industry crop requirements with improved resource-use efficiency

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European agriculture is facing competing demands for food and bioenergy crops. Silvoarable agroforestry (SAF) integrates trees and arable crops on the same area of land. An important benefit of integrated tree and crop systems is that they can make more efficient use of resources and produce more biomass, then when grown separately. However, performance in Europe is variable and methods that combine environmental and economic indicators are needed to evaluate in what circumstances, SAF offers a viable alternative.

Resource efficiency assessment

Data on nineteen Landscape Test Sites (LTS) were randomly selected in Spain, France and The Netherlands and used with the YieldSAFE model (van der Werf et al., 2007) to predict the yield of integrated crops and trees in silvoarable systems (e.g Fig 1). Crops were grown in rotations typical of each LTS and five tree species were selected including Poplar (*Populus* spp), wild cherry (*Prunus avium)*, oak (*Quercus ilex)*, pine (*Pinus pinea)* and walnut (*Juglans* hybr.) Tree density was assumed to be 113 trees ha^{-1} and yields were predicted for 10% and 50% of both the least and most productive portions of each LTS. The Land Equivalent Ratio (LER, eq. 1) was calculated for each tree and crop combination to assess biophysical benefits in comparison with arable and forestry systems.

Sustainability assessment

Graves et al. (2007) assessed the infinite net present value assuming no-payments, pre-2005 CAP payments, and post-2005 CAP payments. Palma et al. (2007a) assessed soil erosion, nitrogen leaching, carbon sequestration and landscape biodiversity. The environmental and economic data were then integrated in a Multi Criteria Decision Analysis (MCDA) with the outranking method "promethee II" to assess the sustainability/performance of each system (Palma et al., 2007b).

Conclusions

• Land Equivalent Ratio (LER) consistently greater than 1 (Fig 2A). Growing crops and trees in integrated SAF systems is more productive than separating them in arable and forestry systems. SAF captures more light, water, and nutrient resources per unit area than the respective monoculture systems (Fig 3).

•The performance of sustainability of arable systems increased when CAP payments were included (Fig 2B). The opposite was true for the SAF, indicating that CAP payments favours arable systems. Nevertheless, SAF is preferable to the "Status Quo" under all payment schemes, and that it would also be preferable to maximize use of SAF on the better land within each LTS (Fig 1B: 50% SAF113 Best Land).

•With its capacity to increase biomass productivity because of greater resource capture, SAF could be an important means of addressing the increased demand for bioenergy crops in Europe, at the same time delivering environmental benefits.

Eq. 1: $$LER = \frac{Tree\ silvoarable\ yield}{Tree\ monoculture\ yield} + \frac{Crop\ silvoarable\ yield}{Crop\ monoculture\ yield}$$

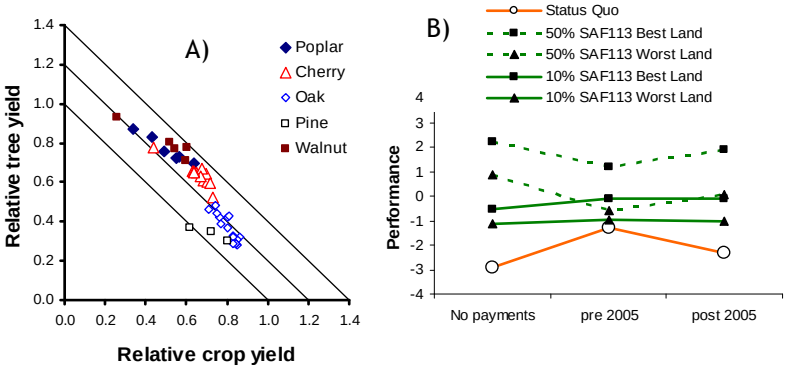

Figure 2. A) Land Equivalent Ratio (LER) of silvoarable agroforestry plot scale results for different tree species. B) Results from multicriteria analysis with performance of economic and environmental indicators under different system and payment scenarios in Spain, France and the Netherlands.

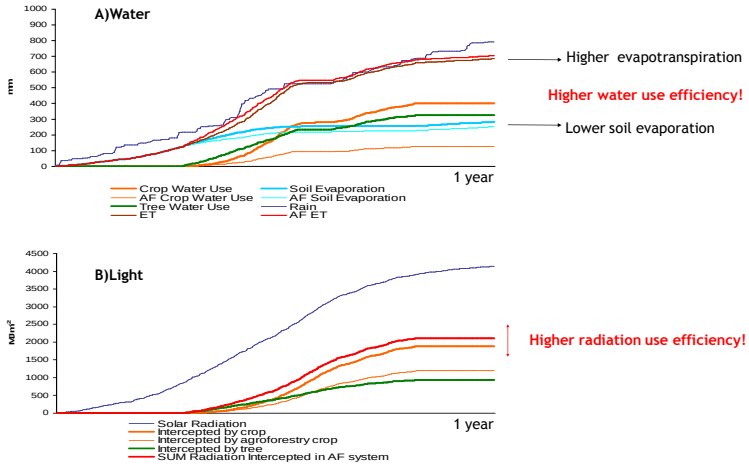

Figure 3. Typical water (A) and light (B) resource uptake during one year in a mature silvoarable agroforestry system, showing higher resource use efficiency. Outputs from YieldSAFE (van der Werf et al., 2007)

References

Graves et al 2007.Ecological Engineering, 29: 434-449.
Palma et al. 2007a. Agri Ecos & Env, 119: 320-334.
Palma et al. 2007b. Ecological Economics, 63: 759-767.
van der Werf et al. 2007. Ecological Engineering, 29: 419-433.

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